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ABSTRACT

To test the effectiveness of teaching machine technology, an experiment was conducted in which an existing course in "Forestry Camp Watershed Fire Training" was translated to teaching machine format and delivered via the Videosonic Teaching Machine. A 252-step lesson was administered to 34 firemen recruits. A pretest, posttest, and retention test were administered and results were compared with the results for 259 experienced firemen who took the same exam but were not exposed to the training. Recruits showed substantial improvement and their test scores exceeded those of veteran firemen. Responses to an opinion questionnaire revealed that trainees were in favor of the new technique. An outline of the curriculum and a sample opinion questionnaire are included. (EMH)

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"TRAINING FIREMEN USING AN AURAL-VISUAL TEACHING MACHINE"

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(5. 6. 16)

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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A. Background

In September, 1960, with the encouragement of the International Association of Fire Chiefs, the Los Angeles County Fire Department entered into an informal agreement with the Education and Training Research Laboratories to conduct a curriculum experiment utilizing teaching machine technology (1, 2, 3, 4). These joint efforts culminated in the translation of a portion of an existing human-instruction course in "Forestry Camp Watershed Fire Training" into teaching machine format suitable for use on the Videosonic Teaching Machine - Experimental Model (5, 6, 7). An evaluation study was completed early in 1962. This paper describes the administration and results of that study.

B. Summary

A 252-step lesson in "Fire Behavior" was administered to 34 recruit firemen of the Los Angeles County Fire Department by means of five Videosonic Teaching Machine - Experimental Models. Based upon criteria in the form of an externally-applied, written comprehension test with a maximum possible score of 40, the trainees averaged 12.8 points before training, 27.4 points immediately afterward, and 23.0 points one month later. On the same test, 259 experienced firemen and captains selected at random from the Department, representing all types of assignments found in a typical county fire organization, achieved an average score of 15.0 without training in "Fire Behavior" by machine. Responses to an opinion questionnaire revealed that the trainees were decidedly in favor of using the new method in future training situations.

C. Trainee Selection

The objective of the evaluation study was to determine whether or not the lesson in "Fire Behavior" could be taught successfully to firemen solely by means of teaching machines. For the experiment, 34 recruits were drawn at random from fire stations throughout Los Angeles County. None had undergone any training in "Fire Behavior" and all were without any previous experience in learning through teaching machines of any design. All training and testing, excluding the retention post-test, was conducted at the Training Headquarters of the Los

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County Fire Department. Two trainees participated each day until all 34 had completed the pre-testing, machine instruction, and post-testing.

D. Test Preparation

A 40-item paper-and-pencil test of 30-minute duration directly related to course content was validated using a group of 259 firemen and captains assigned to all types of operating duties. The test was then split into forms A and B, each consisting of twenty questions covering subject matter of equivalent comprehensive difficulty and meaning.

E. Test Administration

Forms A and B, each having a 15-minute time limit, were alternated, each serving half the time as the pre-test and half as the post-test. They were then recombined and applied with a 30-minute time limit one month later as a test of retention. The retention test was in each case taken at the trainee's fire station under controlled conditions. Immediately after, an opinion questionnaire was used to elicit responses concerning personal feelings about the new method.

F. Training Method

The lesson in "Fire Behavior" was aural-visual in nature, utilizing 35 mm colored slides and synchronized pre-recorded magnetic tape audio instruction. A 6" x 9" rear-projection screen carried the visual display and an individual headset provided the aural display. Learner responses included written-completion using 8-1/2" x 11" printed forms, multiple-choice using a three-alternative button response panel, and participation in several brief technical experiment-like demonstrations. Lesson content is identified in Appendix A.

G. Training and Testing Schedules

Training was administered in one six-hour period during normal hours of employment with rest and lunch periods interspersed at the discretion of the participants individually, based upon the "self-pacing" principle. In summary, the routine for each trainee was:

Same Day at Training Headquarters, L.A.C.F.D.

1. Pre-test: Form A or B on alternate basis containing 20 items with 15-minute time limit
2. Instruction by teaching machine for approximately six hours, with rest and lunch periods taken individually as required. There was no interaction except between a trainee and his teaching machine
3. Post-test: Form A when B used for pre-test and vice-versa containing 20 items with 15-minute time limit

Thirty Days Later at Local L. A. C. F. D. Station

4. Retention Test: Forms A and B combined containing 40 items with 30-minute time limit
5. Opinion Questionaire

H. Results

Scores achieved on the "Fire Behavior" comprehension test are shown in Table 1 and Figure 1. The Experimental Group attained a pre-training average of only 12.8, which was significantly (at .05 level) less than the 15.04 mark of the Experienced Group. After training, however, the Experimental Group scored 27.4, or 83% better than the Experienced Group. The net gain was just over 100%. One month later, the Experimental Group retention average dropped slightly to 23.0, but still remained far above both the pre-training level and the Experienced Group level. The degree of comprehension and the amount of knowledge retained was of practical as well as statistical magnitude.

Table 1

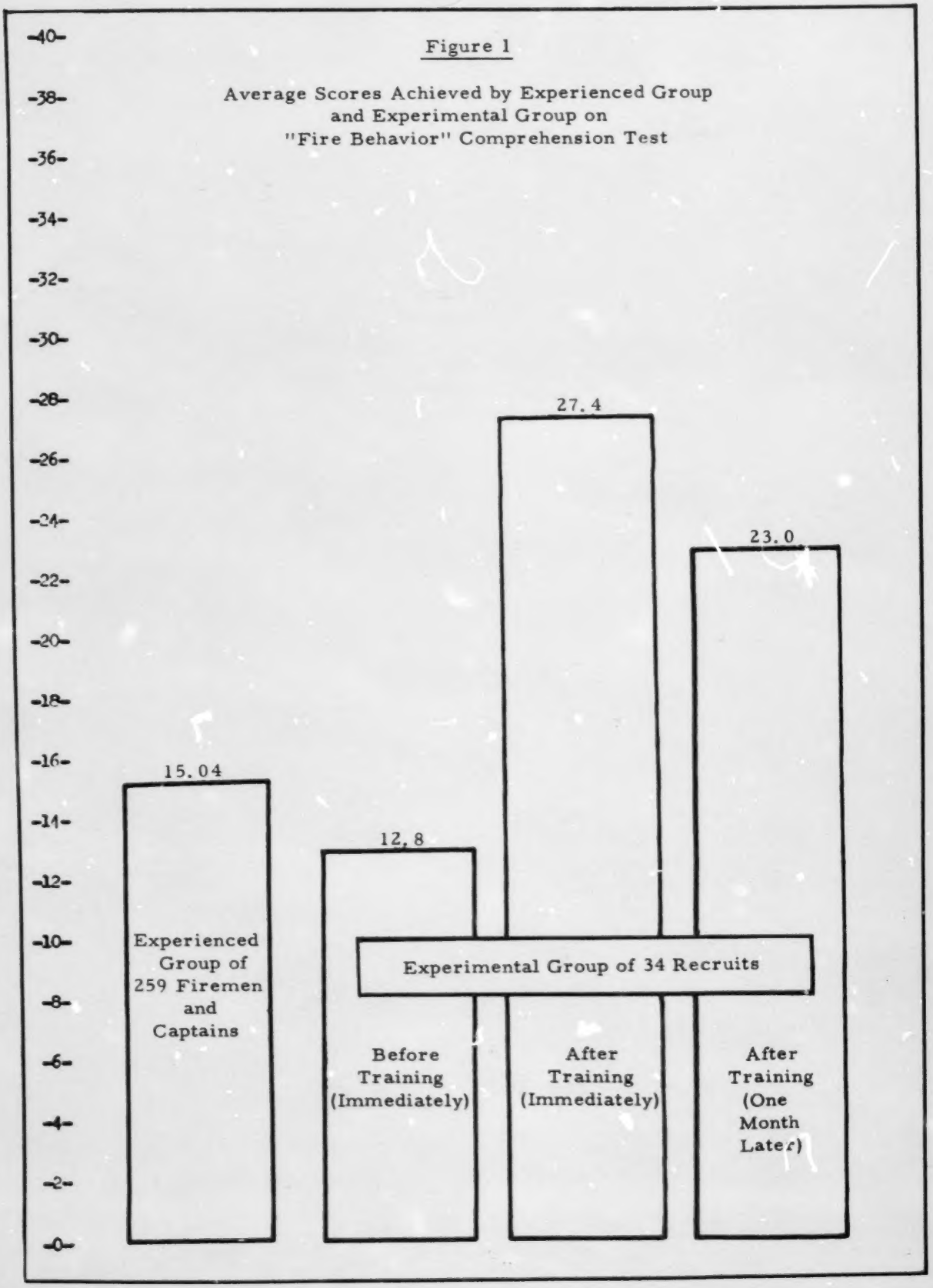
Means and Standard Deviations Achieved on Paper-and-Pencil "Fire Behavior" Comprehension Test

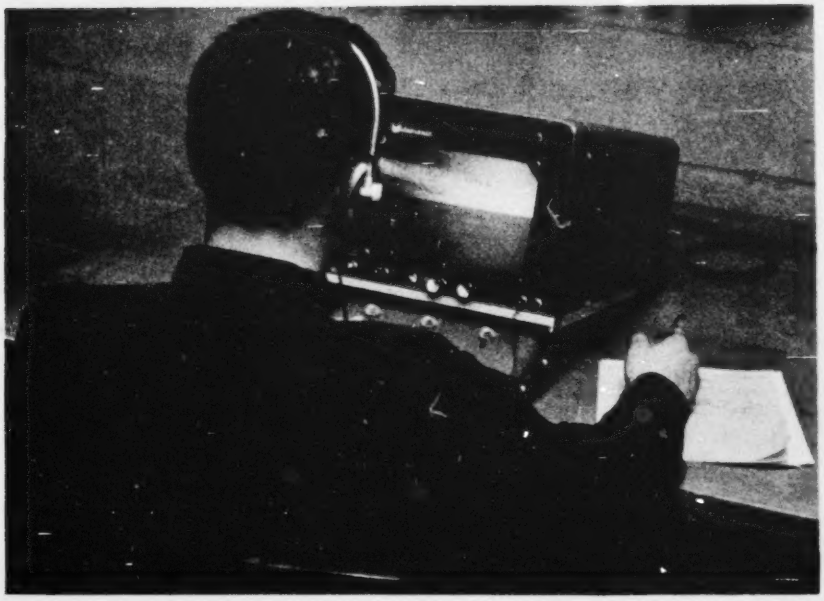
Test Situation	Mean	S.D.
I. Validation Group (all 40 items) N=259	15.04	4.5
a. Validation Group (Form A: 20 items) N=259	*7.63	2.6
b. Validation Group (Form B: 20 items) N=259	*7.37	2.8
II. Pre-Training Group (20-item scores extended for comparison) N=34	12.88	5.43
III. Post-Training Group (20-item scores extended for comparison) N=34	27.41	5.82
IV. Retention Group (all 40 items) N=34	23.00	5.04

*Statistically Equivalent

Figure 1

Average Scores Achieved by Experienced Group
and Experimental Group on
"Fire Behavior" Comprehension Test





Opinion Questionaire

The opinion questionaire, as shown in Appendix B, is far too detailed to be treated here in its entirety. Instead, only those responses which appear most pertinent will be cited.

1. Parts of lesson most difficult:

   Weather: wind, humidity, and temperature.

   Comment:

   Test results tend to support this, suggesting that the instruction pertaining to weather, and especially the teaching points dealing with relative humidity, might be in need of slight modification.

2. Features most liked:

   Absence of distraction; opportunity to make mistakes without feeling stupid; chance to participate in instructional process.

   Comment:

   These observations are not surprising. Such impressions, particularly regarding the aspect of privacy, have come to be expected as a result of machine instruction, particularly with adults.

3. Features most disliked:

Lack of opportunity to review past subject matter in the machine at will; insufficient time allowed for written completion steps; too much material in one day.

Comment:

It is believed that the key to all three comments lies in the third; i. e., too much material in one day. The lesson was originally designed for presentation over a period of three days, but scheduling difficulties forced adoption of the massed rather than distributed schedule. It is quite probable that the time permitted for written responses would have been enough and the need for review diminished had the original schedule been used.

4. Use of sound and picture

Neither alone would be as effective as both together.

Comment:

This is merely another of repeated expressions of preference by learners for the utilization of as many sense modalities as possible in the training environment. The notion has the support of both common sense and experimental evidence (8, 9, 10, 11, 12).

5. Summary opinion:

General approval of new method.

Comment:

This response was almost unanimous, but frequently linked with the provision that the lessons be spread out rather than concentrated all in one day.

J. Conclusion

Based on both test scores and trainee opinion, substantial improvements in fire behavior comprehension were realized as a result of the machine-instruction. The initial gain, in the neighborhood of 100%, fell off slightly during the succeeding month, but the degree of comprehension and the amount of knowledge retained were still far greater than that exhibited before training.

Due to scheduling in an operating fire department, each participant was obliged to take the entire lesson in one day rather than over a span of three days as was the original intention. In view of trainee opinions expressed later, and the abundance of psychological evidence favoring training on a distributed, instead of massed, basis, there is reason to believe that individual performances might have suffered as a result (11, 12). It is therefore hypothesized that this same curriculum administered over a period of three days would produce benefits even greater than those described in this present study.

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Appendix A

"FIRE BEHAVIOR" - - LESSON OUTLINE

(1.4.4.3.6 September 1961)

Main Facts	Teaching Points		Steps		Step No.
1. Using the VIDEOSONIC* Teaching Machine - Experimental Model	1.1	Controlling the machine	1.1.1	Whelan introduction	1
			1.1.2	focusing, volume adjust	2-5
	1.2	Multiple-choice responding	1.2.1	correct response	6-7
			1.2.2	incorrect-correct response	8-9
	1.3	Course rules			10
2. Historical Introduction	2.1	Pre-historic society			11
	2.2	Greek and Roman society			12
	2.3	Cavendish and rules of combustion	2.3.1	oxygen atmosphere	13-14
			2.3.2	flammability	15-16
3. Triangle of Fire	3.1	Fuel			17-18
	3.2	Oxygen			19
	3.3	Heat	3.3.1	must be present	20-21
			3.3.2	removed by cooling	22
			3.3.3	produced by gases burning	23-24
	3.4	Review 3.1-3.3		(7 written-completion)	25
4. Oxidation and Ignition	4.1	Element combined with oxygen			26-27
	4.2	Ignition	4.2.1	ignition temperature	28-29
			4.2.2	heat to sustain combustion	30
			4.2.3	heat to cause ignition	31-36
	4.3	Review 4.2		(7 written-completion)	37
5. Sources of Heat	5.1	Four common sources			38
	5.2	Direct application of flame			39
	5.3	Friction		(2 experiments)	40-41
	5.4	Static electricity			42-44
	5.5	Review 5.1-5.4		(3 written-completion)	45
	5.6	Spontaneous heating	5.6.1	definition	46
			5.6.2	speed of oxidation	47-48
			5.6.3	conditions necessary	49-50

Main Facts	Teaching Points		Steps		Step No.
6. Heat Transfer	6.1	Radiation, Convection and Conduction			51-53
	6.2	Laws of Radiation	6.2.1	Laws 1, 2 and 3	54
			6.2.2	Law of Direction	55
			6.2.3	Law of Amount	56
			6.2.4	Law of Absorbtion	57
			6.2.5	Law of Distance	58-64
			6.2.6	(statement written-comp.)	65
	6.3	Convection			66
	6.4	Conduction	6.4.1	indirect contact	67
			6.4.2	thermal conductivity	68
	6.5	Review 6.1-6.4		(multiple-choice)	69-72
7. Breaking the Fire Triangle	7.1	Review 3.1-6.4		(7 written-completion)	73
				(multiple-choice)	74-79
	7.2	Reducing heat, removing oxygen and fuel			80-82
	7.3	Reducing heat	7.3.1	review and conduction	83
			7.3.2	illustrate conduction	84-86
			7.3.3	B.t.u. definition	87
			7.3.4	B.t.u.'s for 1°F	88-89
			7.3.5	B.t.u.'s for several °F	90-91
			7.3.6	B.t.u.'s for several gallons several °F	92-93
			7.3.7	latent heat of vaporization	94-97
			7.3.8	dirt for cooling	98
	7.4	Removing oxygen	7.4.1	composition of air	99
			7.4.2	% oxygen for personal safety	100
			7.4.3	dirt for displacing oxygen	101
			7.4.4	inert gas	102
			7.4.5	foam-dirt compared	103
			7.4.6	dry chemical	104
	7.5	Removing fuel	7.5.1	controlled burning	105
			7.5.2	stopping fuel flow	106
	7.6	Review 7.3		(7 written-completion)	107
	7.7	Forward bond			108

Main Facts	Teaching Points		Steps		Step No.
					109
8. Factors Influencing the Spread of Fire	8.1	Burning condition of fuel			
	8.2	Wind-general	8.2.1	direction	110, 112
			8.2.2	patterns	111
			8.2.3	effects	113-114
				(7 written-completion)	115
			8.2.4	pressure	116-119
			8.2.5	shapes of burns	120
			8.2.6	oxygen	121
			8.2.7	terrain effect	122
			8.2.8	wind direction and the Pacific Ocean (3 written completion)	123-124
			8.2.9	effect of mountains and heating	125-128
	8.3	Santa Ana Wind	8.3.1	definition	129
			8.3.2	high pressure-low pressure	130-131
			8.3.3	direction	132
			8.3.4	damage	133
			8.3.5	characteristics	134
	8.4	Winds caused by fire	8.4.1	three types	135
			8.4.2	dust whirl (dust devil)	136
			8.4.2	fire whirlwind	137
			8.4.3	fire storm	138-139
	8.5	Review 8.2-8.4		(31 written-completion)	140-143
	8.6	Forward bond			144
	8.7	Review 8.2-8.4		(31 written-completion)	145-146
	8.8	Temperature-Humidity	8.8.1	review ignition temp.	147-148
			8.8.2	review quantity of heat	149
			8.8.3	review brush vapors	150-151
			8.8.4	review % oxygen in air	152
			8.8.5	composition of air	153-156
			8.8.6	capacity and saturation	157-158
			8.8.7	absolute humidity described	159
			8.8.7	relative humidity described	160-161
			8.8.8	calculating relative hum.	162-164
			8.8.9	dewpoint	165-168

Main Facts	Teaching Points	Steps	Step No.
		8.8.10 effect of humidity on fire	169-171, 173
		8.8.11 review Santa Ana	172
		8.8.12 personal safety	174
	8.9 Fuel Moisture	8.9.1 review Cavendish	175
		8.9.2 review heat transfer	176
		8.9.3 transpiration	177
		(35 written-completion)	178-180
	8.10 Review 8.8-8.9		
	8.11 Inversion layers	8.11.1 review physical mixture of air	181
		8.11.2 review effect of heat on air masses	182
		8.11.3 air temperature at altitudes	183-5
		(pattern-completion)	
		8.11.4 characteristics	186-7
		(7 written-completion)	188, 190, 191
		8.11.5 inversion traps	189
	8.12 Topography	8.12.1 definition	192
		8.12.2 man-made changes	193
		8.12.3 exposures	194-197
		8.12.4 soil erosion	198
		(8 written-completion)	
		8.12.5 rain-shadow	199-201
		(1 experiment)	
		8.12.6 precipitation	202-205
		(3 written-completion)	
		8.12.7 slope steepness	206, 209, 210
		8.12.8 review distance law and convection	207-208
		8.12.9 origin of fire	211-213
		8.12.10 uphill fire behavior	214-216
		(3 written-completion)	

Main Facts	Teaching Points	Steps	Step No.
	8.13 Review 8.8-8.12	(53 written-completion)	217-222
	8.14 Canyon Firefighting	8.14.1 width of canyon	223
		8.14.2 wind effect	224-225
		8.14.3 backfiring	226
		8.14.4 windbreaks	227-228
	8.15 Elevation	8.15.1 height	229
		8.15.2 size of fires	230
		8.15.3 caused by lightning	231
		(12 written-completion)	232
	8.16 Forest Fuels	8.16.1 classification	233
		8.16.2 position	234-236
		8.16.3 ground fuels	237-242
		8.16.4 aerial fuels	243
		8.16.5 continuity	244, 246-247
		8.16.6 compactness	245
		8.16.7 heat generation	248
	8.17 Review 8.16	(15 written-completion)	249-250
	8.18 Conclusion of Lesson		251-252

FIRE BEHAVIOR - QUESTIONNAIRE
(1.4.4.3.5 July 1961)

The information requested on this questionnaire is to be used by training specialists at HUGHES to revise and improve the teaching machine lesson in "Fire Behavior." You have our assurance that it will be kept CONFIDENTIAL and anonymous at all times. Your age is _____ Your number is _____

We seek information of four kinds

A. Learning "fire behavior"
B. How the visual information influenced you
C. How the recorded information influenced you
D. Methods of responding

You may refer to the OUTLINE given to you for replies

A. LEARNING "FIRE BEHAVIOR"

1. How much did you learn about fire behavior from the lesson?

   a. ☐ great amount b. ☐ average c. ☐ very little

2. Did the instruction give you an <u>understanding</u> or just information?

   a. ☐ understanding of information b. ☐ some understanding some information c. ☐ just information

3. Is the average human instructor superior to the machine?

   a. ☐ superior b. ☐ same c. ☐ worse

   Explain your answer

4. Assuming that an average human instructor is generally superior, what can we do to improve the machine so it would be at least equal to the human instructor?

5. Assuming that an average human instructor is generally worse, in what ways could he improve so he would be at least equal to the machine?

6. Describe your first personal feelings about the machine as compared with a human instructor.

7. At what point did you feel that the newness of the method disappeared?

8. At what point did you feel confident that the method would be worthwhile to you?

9. At what point, if any, did you feel the method might actually be an improvement over human instruction?

10. If you have worked with other teaching machines or self-instructional methods (such as correspondence courses), which were these and how does this method compare with them?

11. What part or parts of the lesson were least clear in terms of understanding?

12. What part or parts of the lesson were most clear in terms of understanding?

13. What did you dislike the most?

14. What did you like the most?

15. Here are eight different areas in which the teaching machine might be used but with special lessons for different purposes. Examine each one and if you have any ideas about how it should be used, or not used, please use the space provided.

a. Business and Industry

b. Government-Military

c. Training Assistance for Developing Nations

d. Government-Non Military

e. Education (Kindergarten to Senior High)

f. Education (College)

g. Adult or Special Education

h. At home

B. VISUAL INFORMATION

1. Comments about clarity of visual image

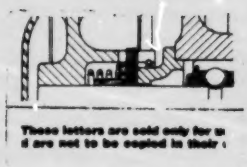
2. Comments about colors used

3. Comments about eye fatigue, headache, or personal discomfort

4. Sketch two visual objects in your mind at this moment which you recall from the slides

#1

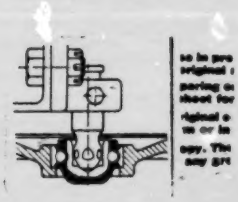
#2

5. 

How do you feel about the layout of this slide for learning?

a. ☐ dislike
b. ☐ satisfactory
c. ☐ like

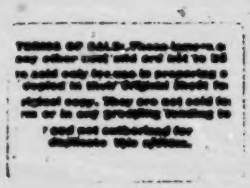
Explain

6. 

How do you feel about the layout of this slide for learning?

a. ☐ dislike
b. ☐ satisfactory
c. ☐ like

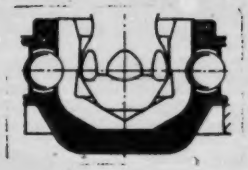
Explain

7. 

How do you feel about the layout of this slide for learning?

a. ☐ dislike
b. ☐ satisfactory
c. ☐ like

Explain

8. 

How do you feel about the layout of this slide for learning?

a. ☐ dislike
b. ☐ satisfactory
c. ☐ like

Explain

9. Things you particularly liked about the slide presentations

10. Things you particularly disliked about the slide presentations

C. RECORDED INFORMATION

1. Comments about clarity of the instructor's voice

2. Comments about speed of voice and time given for thinking about and writing answers on the form

3. Suppose the sound was eliminated completely and all instruction appeared visually on slides. Would this seriously affect learning? Explain.

4. While the instructor's voice was heard throughout the lesson, on at least three different occasions, other voices were used. Can you recall them?

5. Sound effects were used several times. One sound in particular was used more than once. Which one was it?

6. What other sound effects were used?

7. Do you think the sound effects had any real value in helping you recall the instruction afterward?

8. Could other sound effects have been used to your advantage in understanding or learning? At what points in the lesson?

D. METHODS OF RESPONDING

1. The machine you used had three choices: A, B, or C. What would be gained from the learning point of view by increasing this to four choices (A B C D) or five choices (A B C D E)?

2. Several different methods were used in connection with the write-in or written-completion response.

   a. How do you feel about the "timed" answer for which a specific time time was given?

b. How do you feel about the written answer for which an unlimited time was given?

3. How did you like using the separate "Form" for writing answers? Can you make any suggestions for changing or automating this?

4. When using the separate "Form," did you at any time refer back to an earlier written answer?

5. Did you take any written notes? ☐ Yes ☐ No

6. If the answer in 5 is "yes," will you briefly describe how extensive and detailed they are and whether you referred to them during your session with the machine.

7. Do you have any preference between the multiple-choice (button) response and the written-completion response? If "yes," please explain your answer.

8. Can you think of a lesson which might require talking to the machine rather than just writing an answer or selecting the A, B, or C button?

9. Won't you use the space below to make any comments in addition to those already provided?